Climate change over western North America

Steve Hostetler, Andrea Allan and Jay Alder

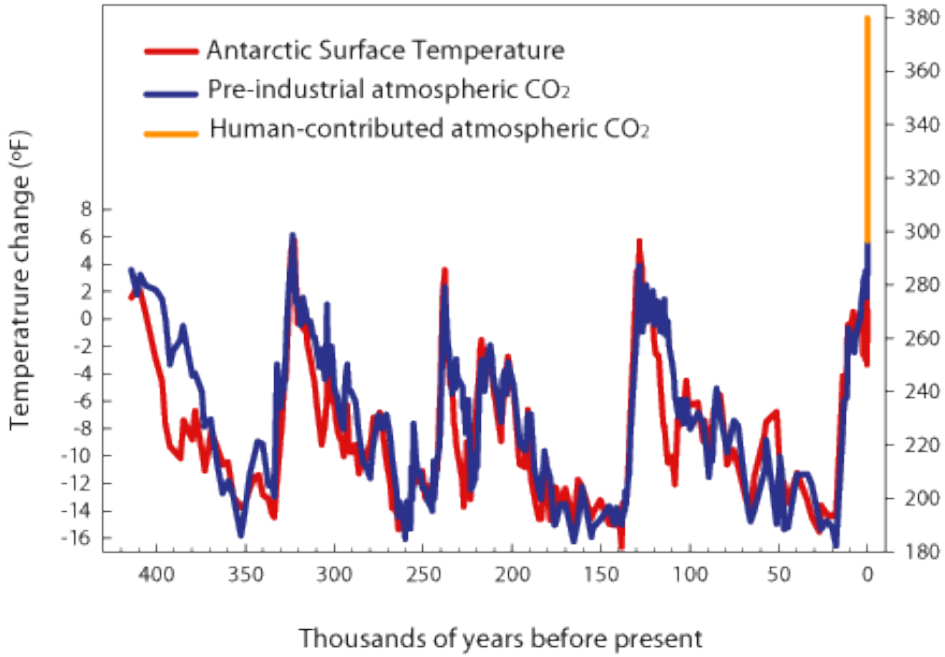
Environmental Computing Center, College of Atmospheric and Oceanic Sciences, Oregon State University

USGS National Research Program, Global Change Program, and NCCWSC, NSF Paleoclimate Program, College of Science, Oregon State University

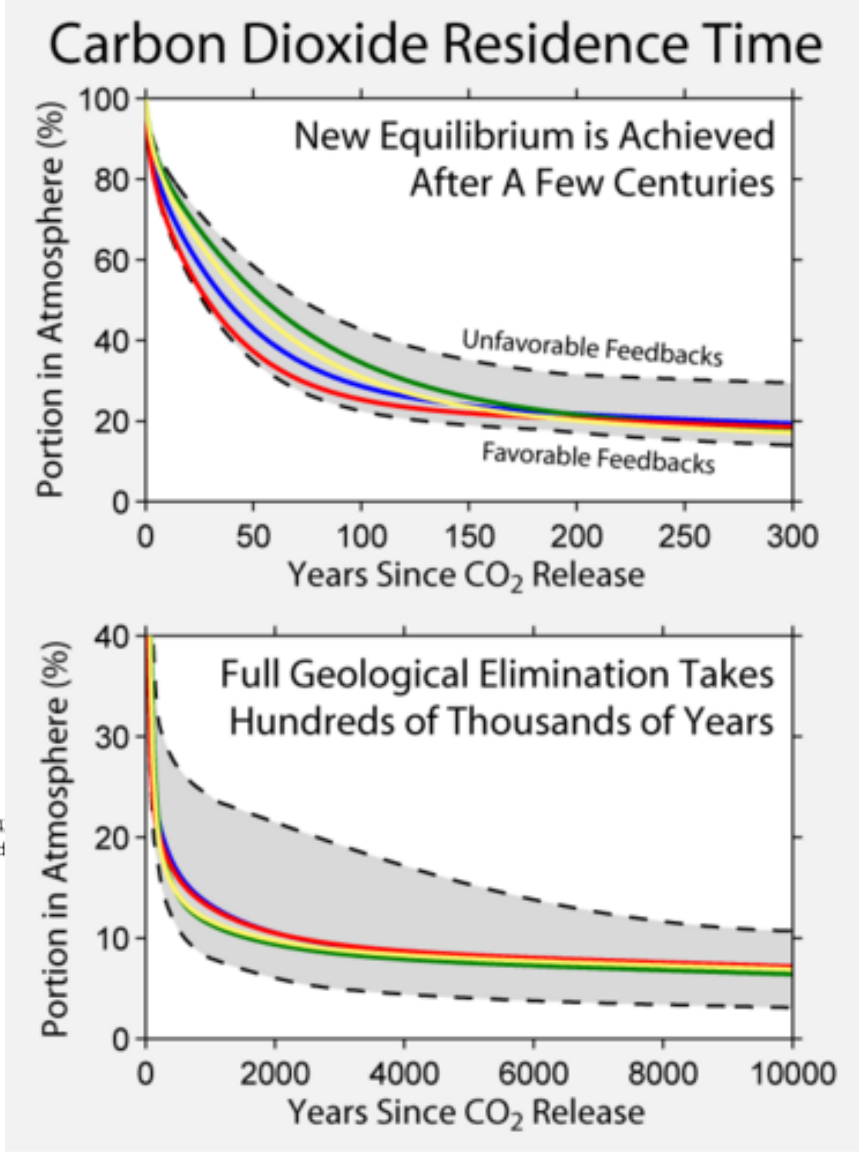
Outline

1. **Climate change– where we have been, where we are now, where we are going**
2. **Global climate models– uncertainties and agreements**
3. **Dynamical Downscaling**
   - **50 km: The Pacific North American Pattern (PNA)**
   - **Model uncertainties**
   - **15 km: Water and energy balance implications for hydrology and wildfire**

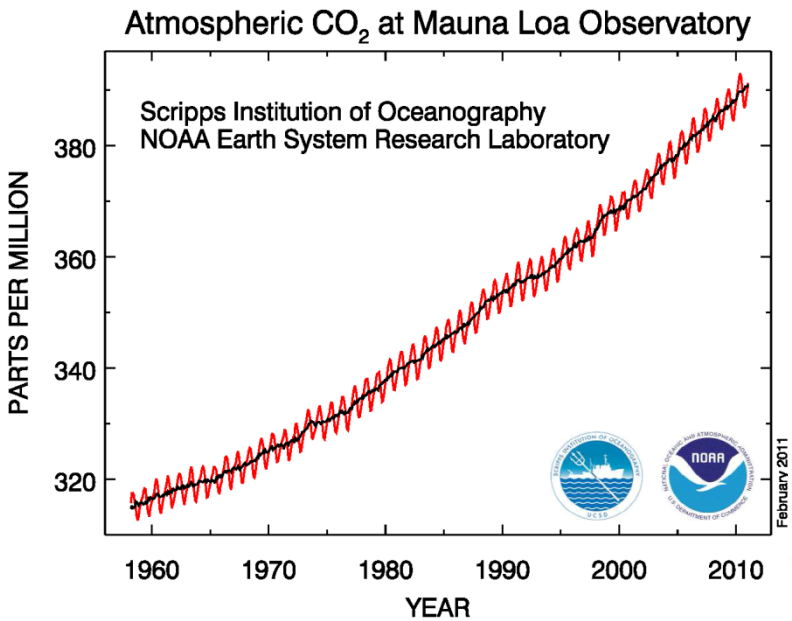
What the records tell us…

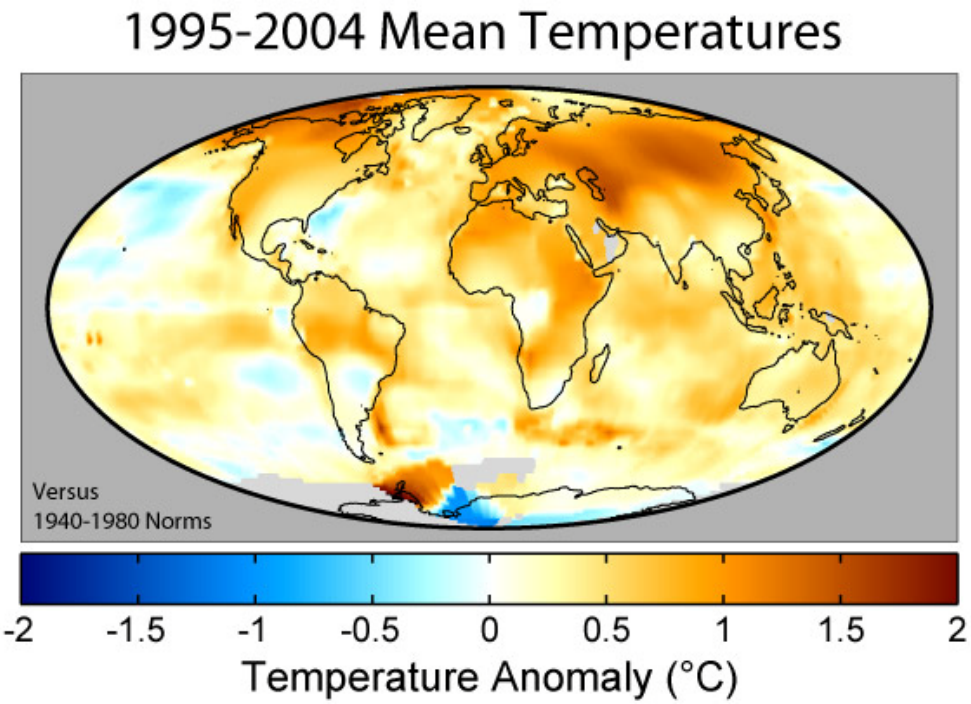


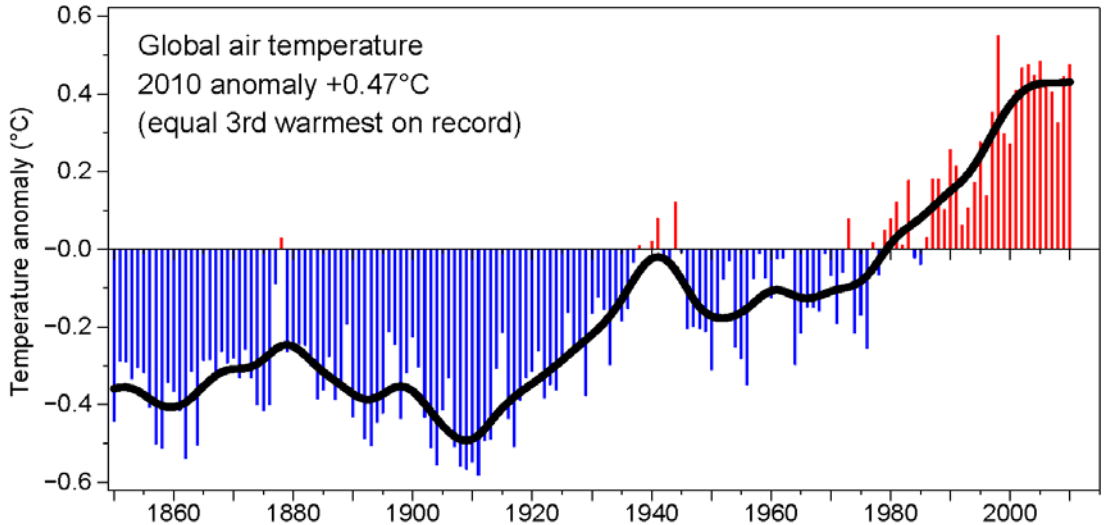
Data Sources:
Atmospheric CO_2 prior to 3000 years ago and Antarctic Surface temperature prior to 100 years ago: J.R., Petit, Jouzel J., et al. 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. Nature 399:4
Pre-industrial CO_2 40-3000 years ago: Indermühle A., T.F. Stocker, F., et. al. 1999, Holocene carbon-cycle dynamics based CO_2 trapped in ice at Taylor Dome, Antarctica. Nature 398, 121-126.
Modern CO_2: Keeling, C.D. and T.P. Whorf. 2005. Atmospheric CO_2 records from sites in the SIO air sampling network. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.



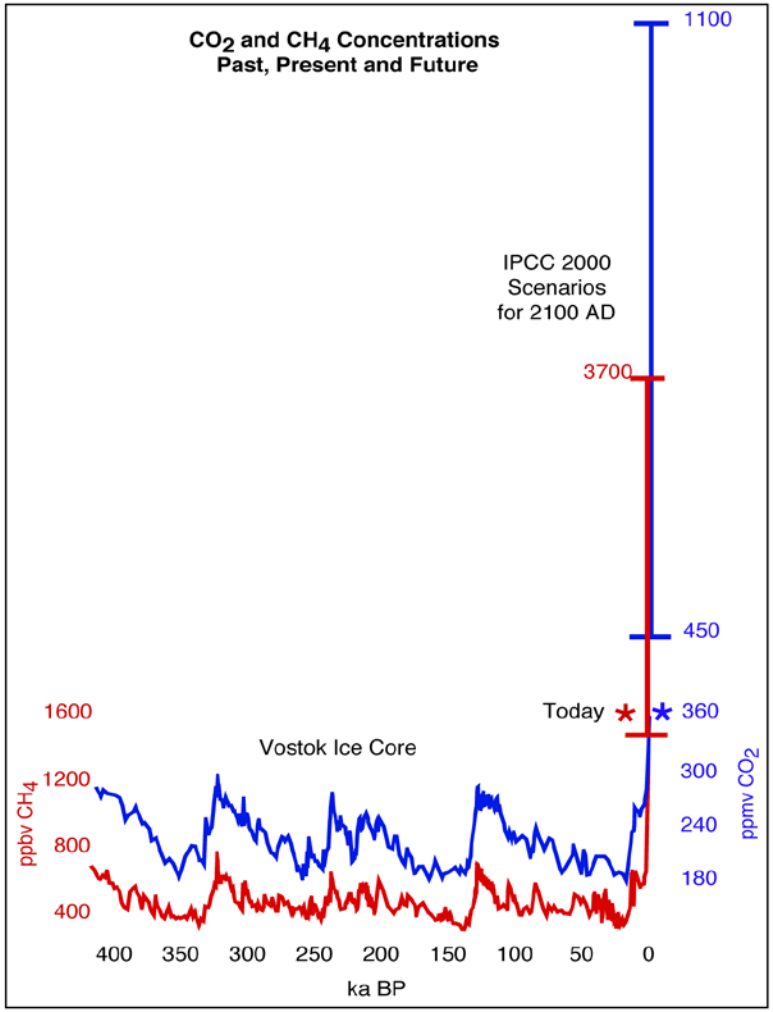
What the records are telling us…







Where we might be headed



Paleoclimate, Global Change and the Future

Alverson, Bradley and Pederson eds., 2002

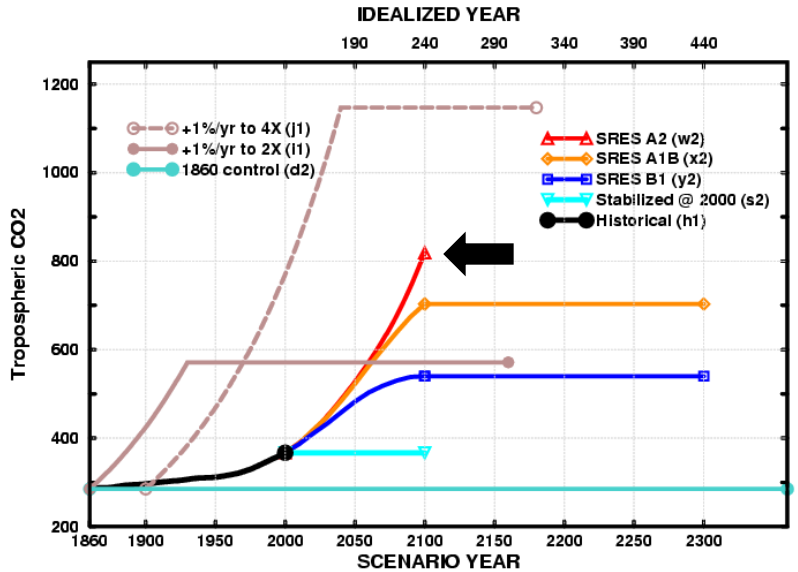
Chapter 1: F. Oldfield, K. Alverson, fig. 1.6, p. 6

GLOBAL CHANGE IGBP

PAGES PAST GLOBAL CHANGES

IPCC scenarios for climate models

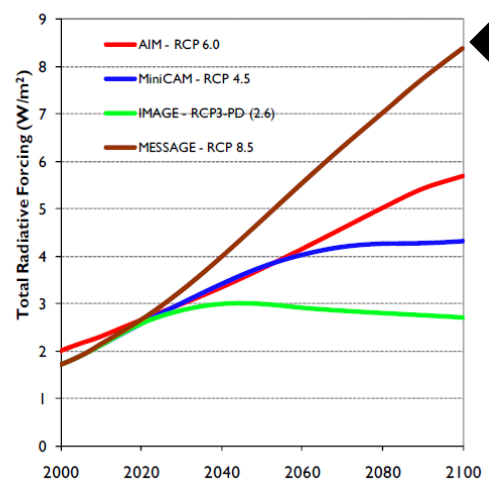
AR4



AR5

*Representative Concentration Pathways**

- **RCP8.5 (IIASA/MESSAGE)**
  - >8.5 W/m^2 in 2100,
  - Rising
- **RCP6.0 (NIES/AIM)**
  - ~6 W/m^2 at stabilization after 2100
  - Stabilization without exceeding target
- **RCP4.5 (PNNL/MiniCAM)**
  - ~4.5 W/m^2 at stabilization after 2100
  - Stabilization without exceeding target
- **RCP2.6 (PBL/IMAGE)**
  - <3 W/m^2 in 2100
  - peak & decline stabilization

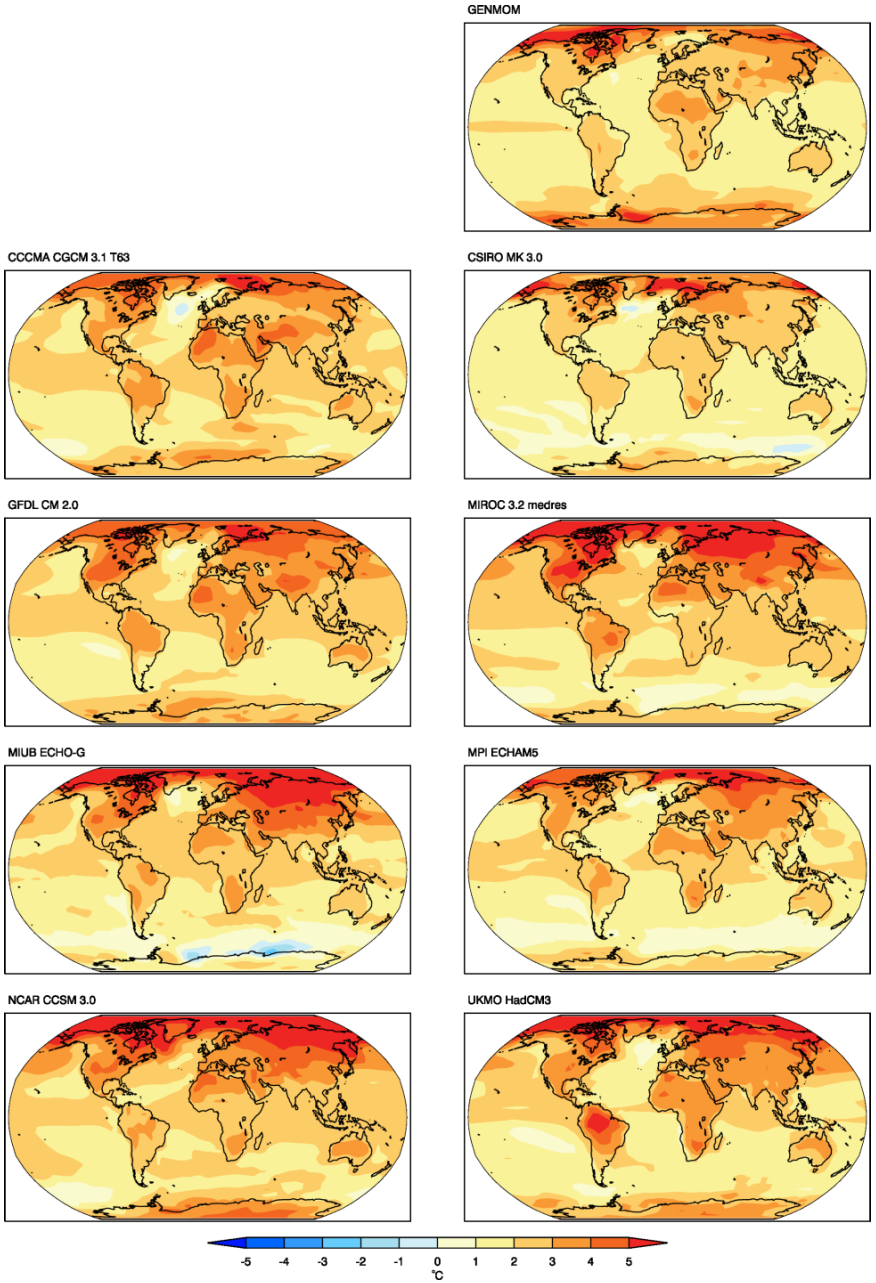


956 ppmV

*http://www.iiiasa.ac.at/web-apps/tnt/RcpDb
Moss et al (2010) doi:10.1038/nature08823

Top: R. Stouffer, K. Taylor, J. Meehl and many others
Bottom: S. Emori

AOGCM sensitivity to CO_2

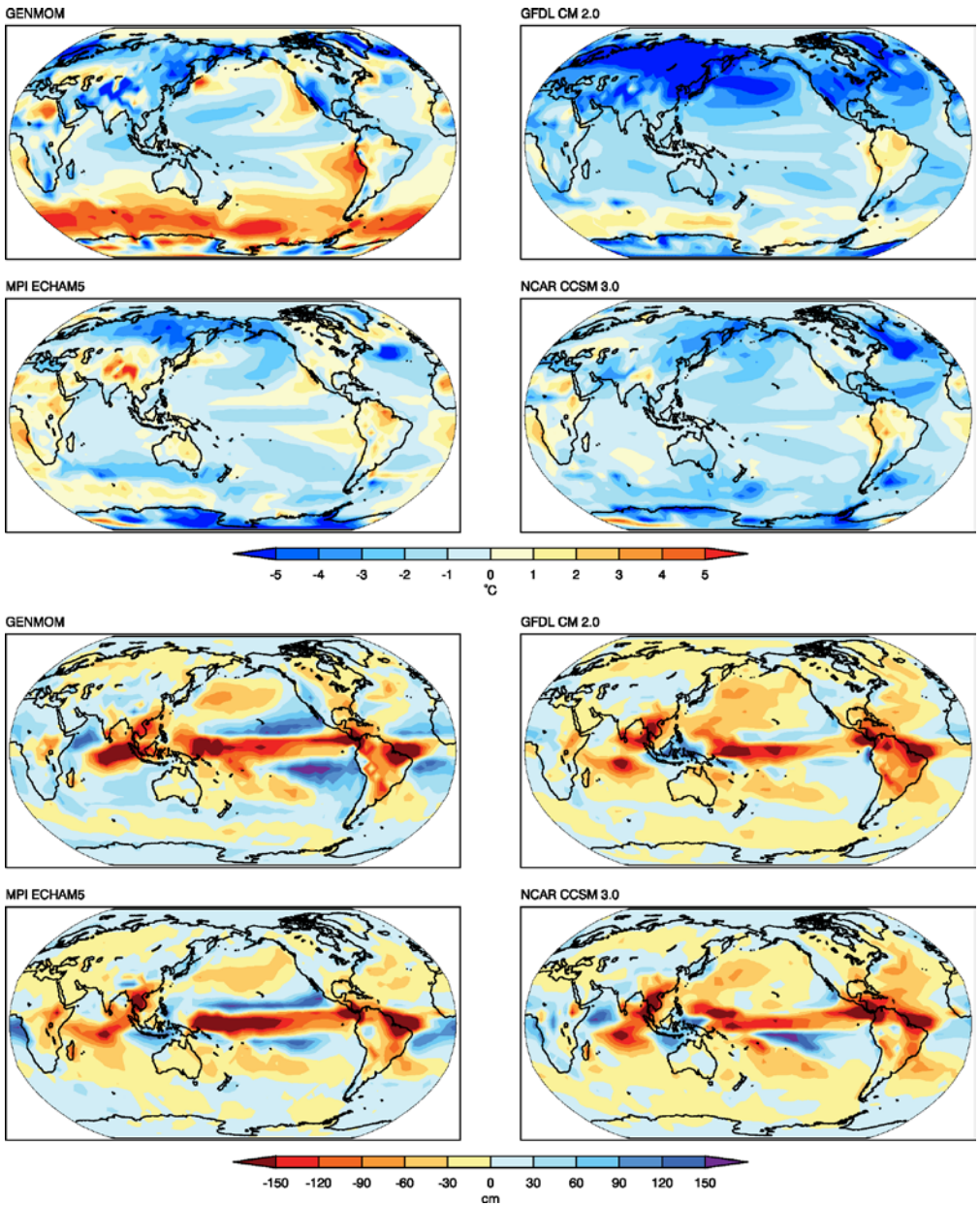


Alder et al, unpublished

Models versus observations (annual)

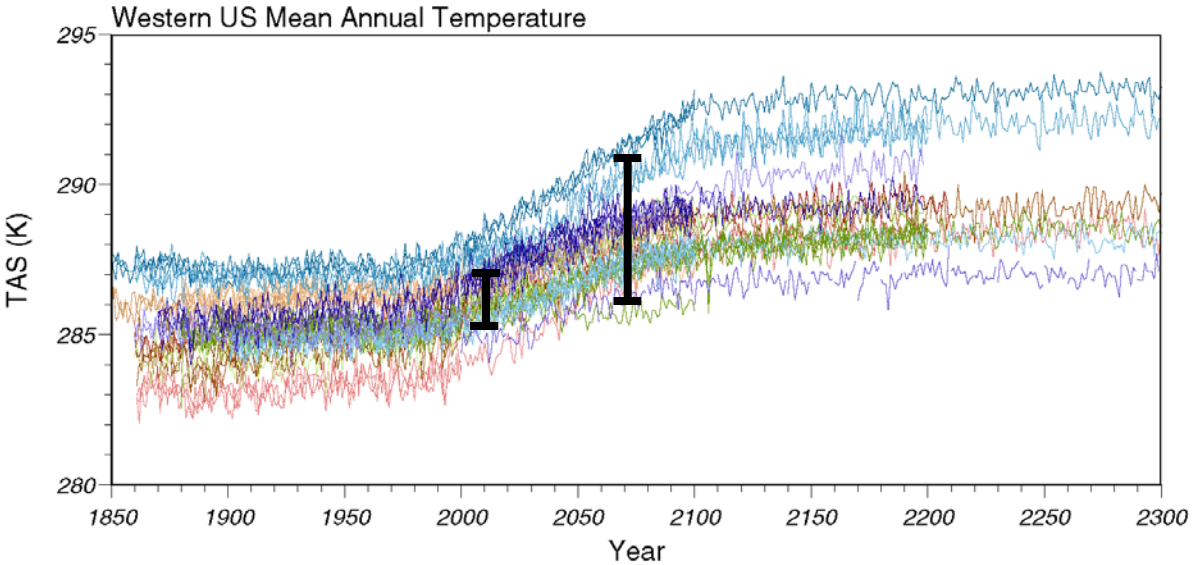
2-m Temperature
Model minus Obs

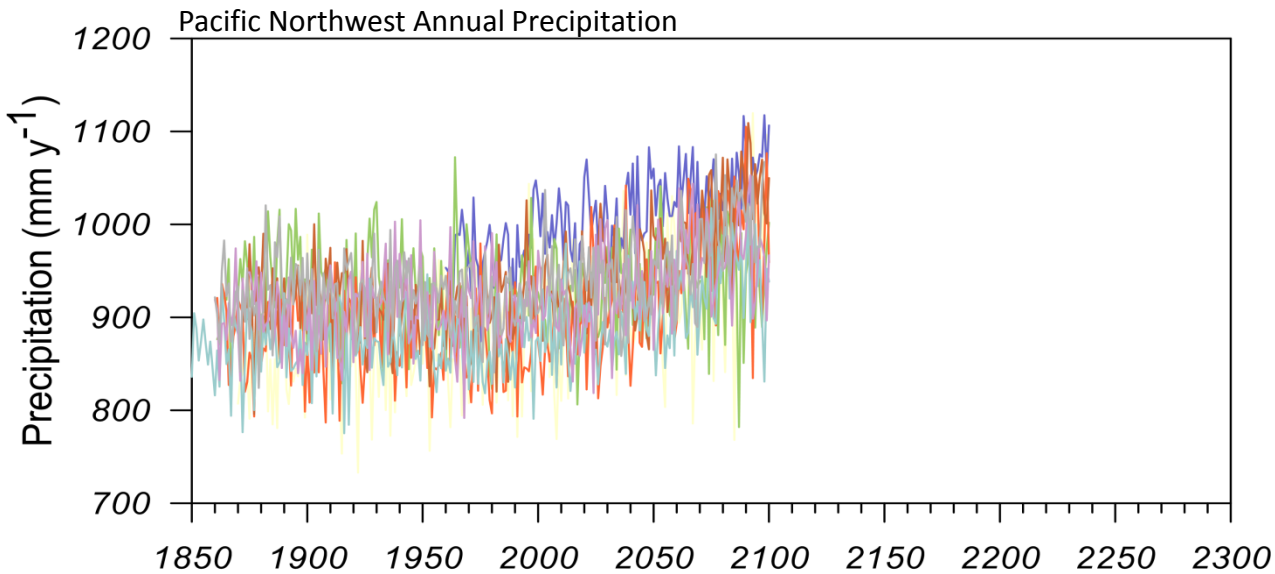
Precipitation
Model minus Obs



Alder et al, 2011

IPCC AR4 AOGCM simulations



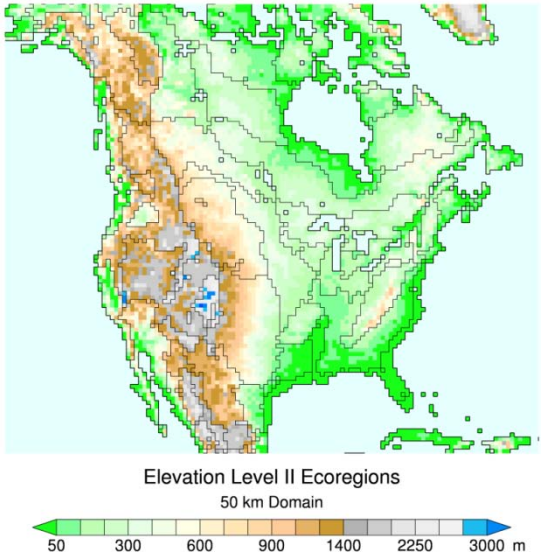


(Top Figure: P. Bartlein, Univ. of Oregon)

50 km Domain (3/6 hr)

Driving GCM Simulation Period

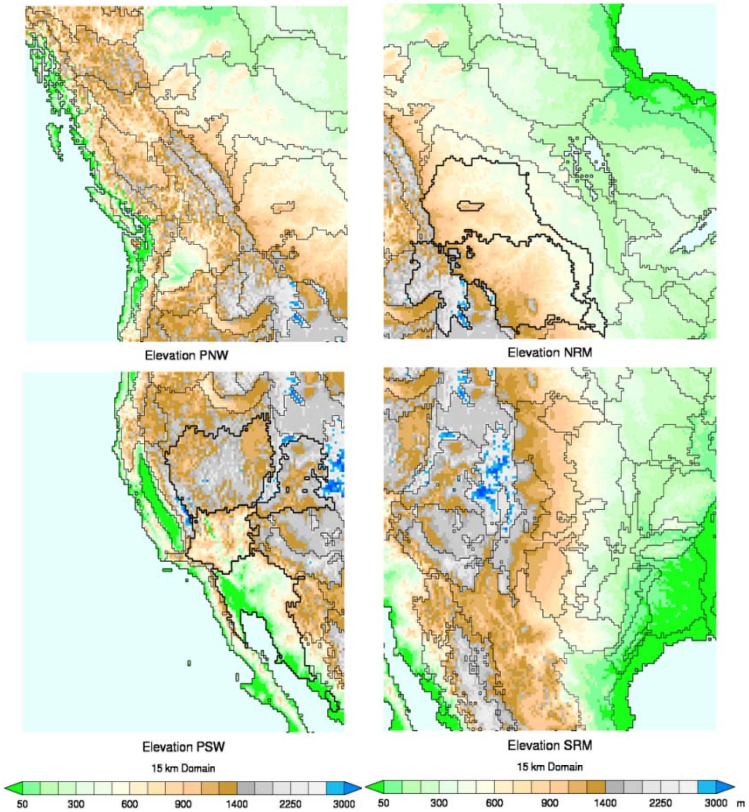
NCEP 1982-2010
ECHAM5 (20C, A2) 1860-2100
GFDL (20C, A2) 1968-2000 2038-2070
GMA2 (A2) 1960-2100
GM85 (“AR5_8.5”) 1990-2100



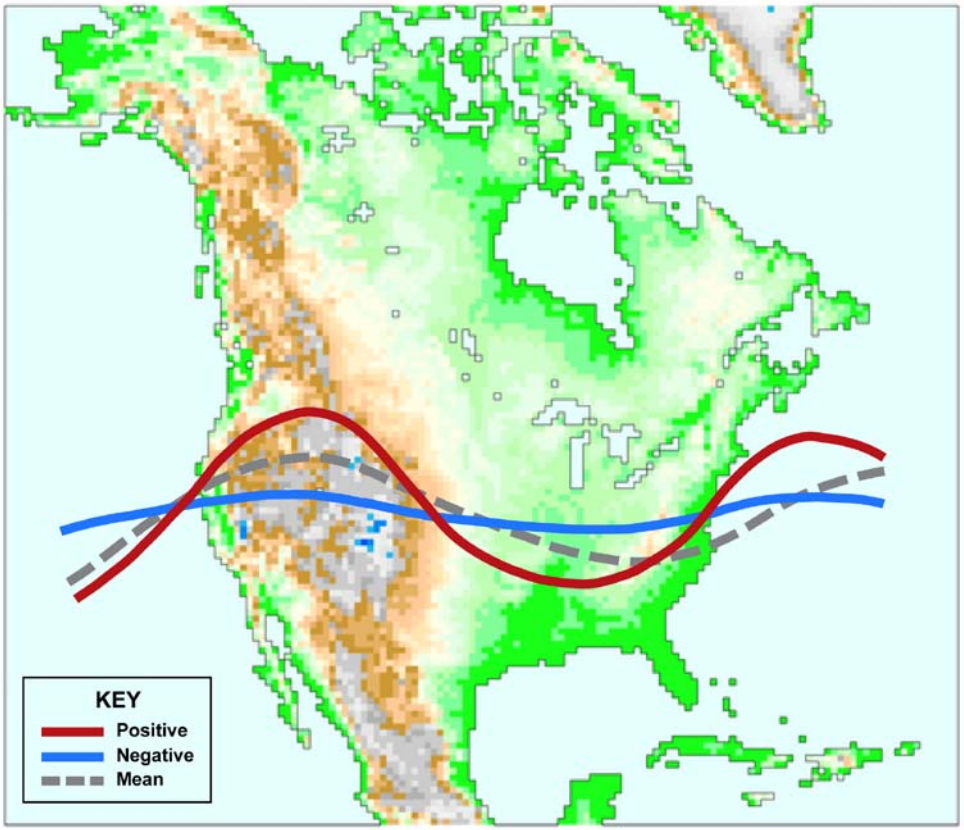
15 km Domains (3 hr)

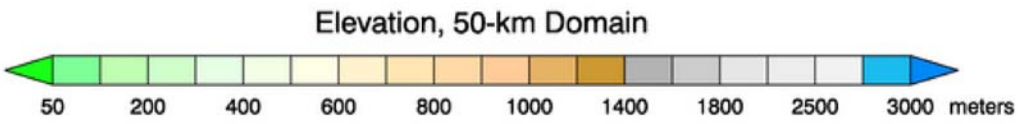
Driving GCM Simulation Period

NCEP 1968-2010
ECHAM5 (20C, A2) 1968-2000 2010-2100
GFDL (20C, A2) 1968-2000 2038-2070
GMA2 (A2) 1968-2000 2010-2100
GM85 (“AR5_8.5”) 1990-2100

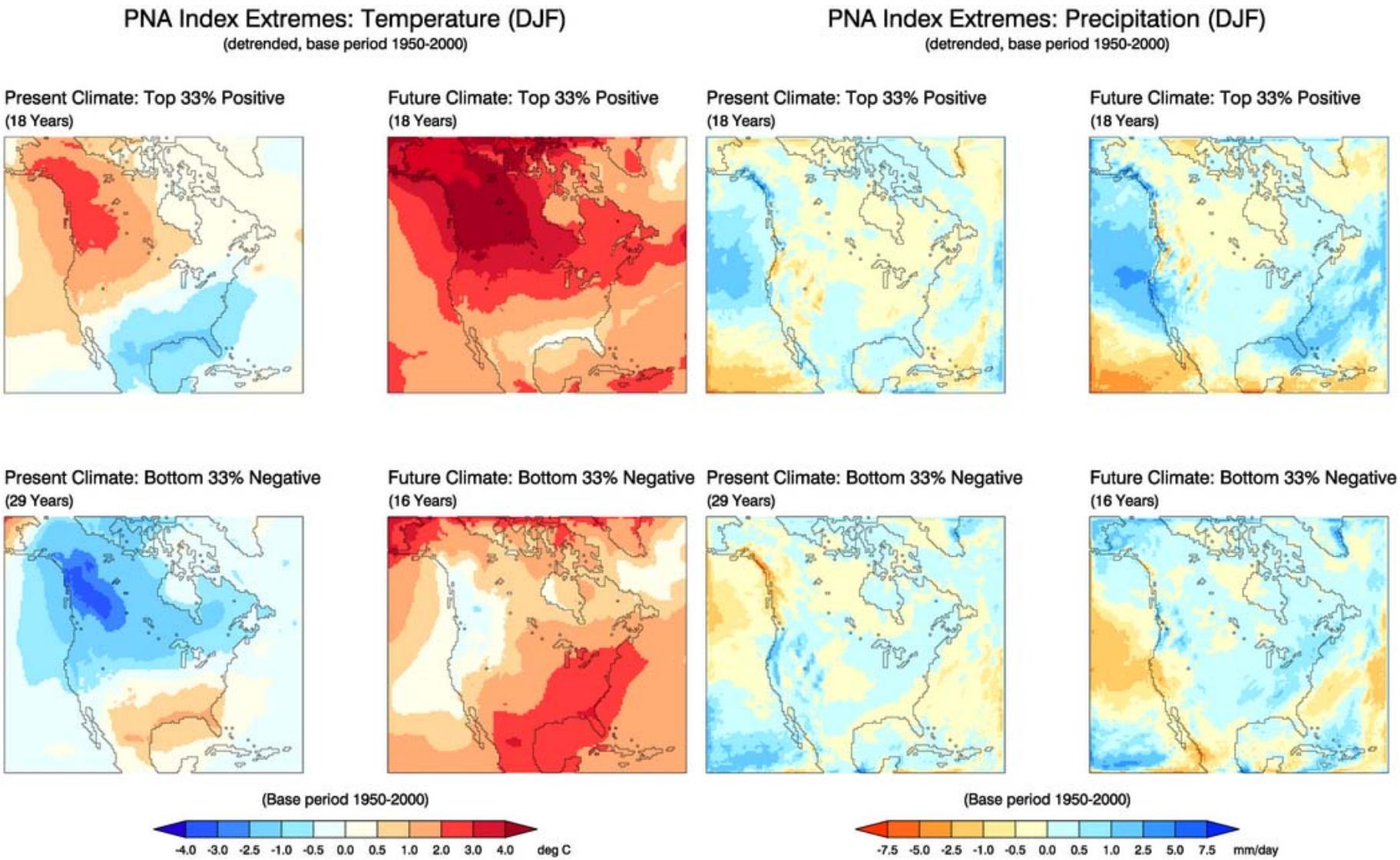


The Pacific North American Pattern



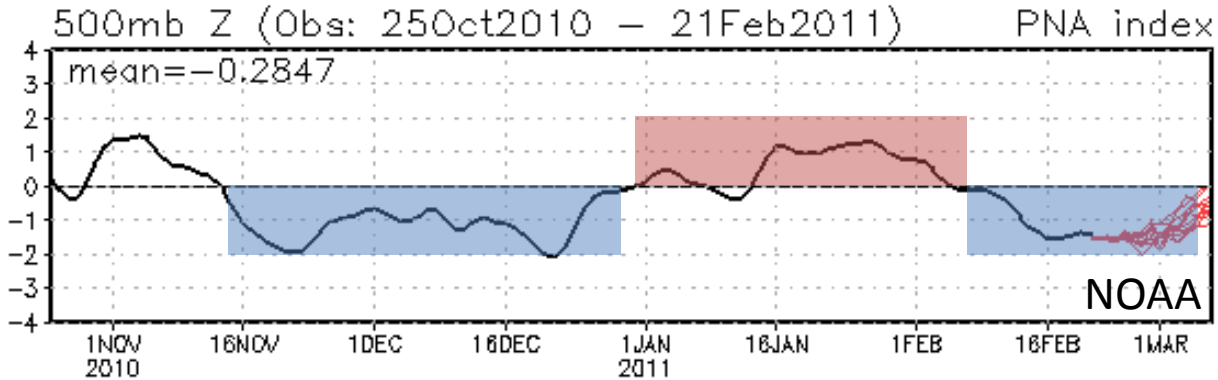


Present versus future PNA

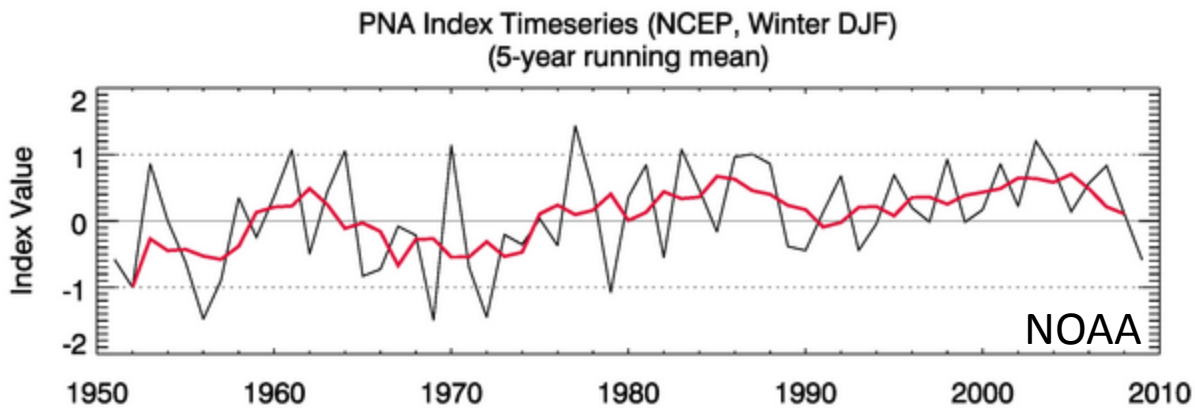


The nature of the PNA

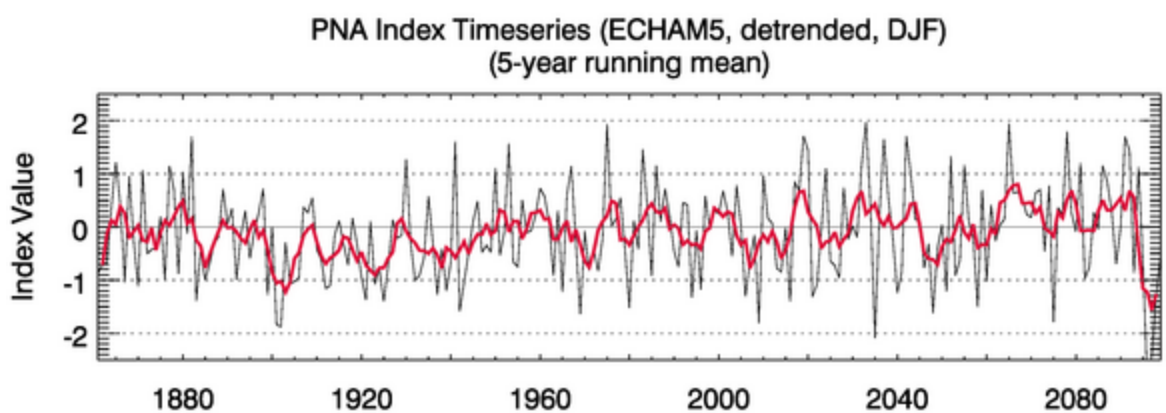
Intra-annual



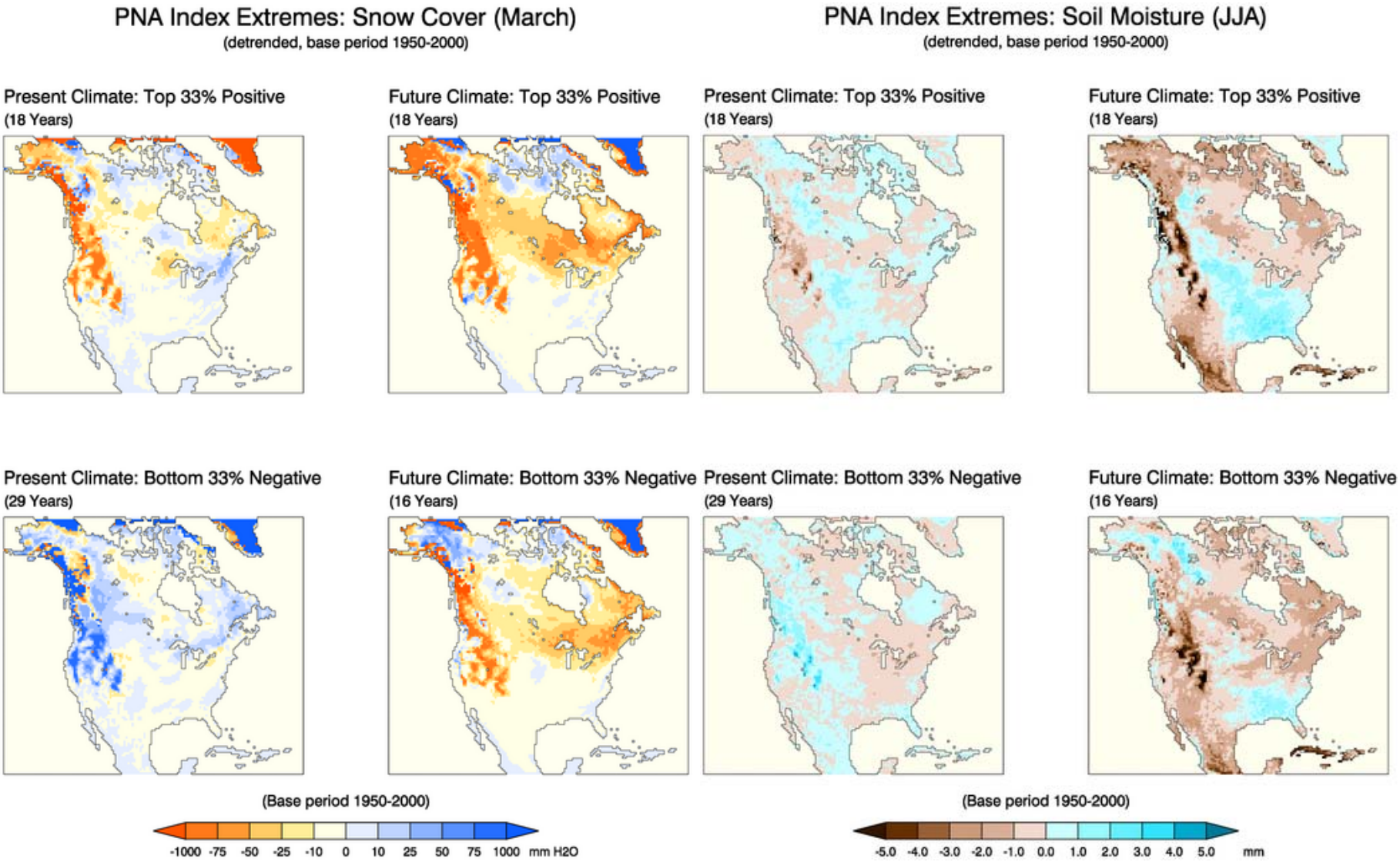
Interannual



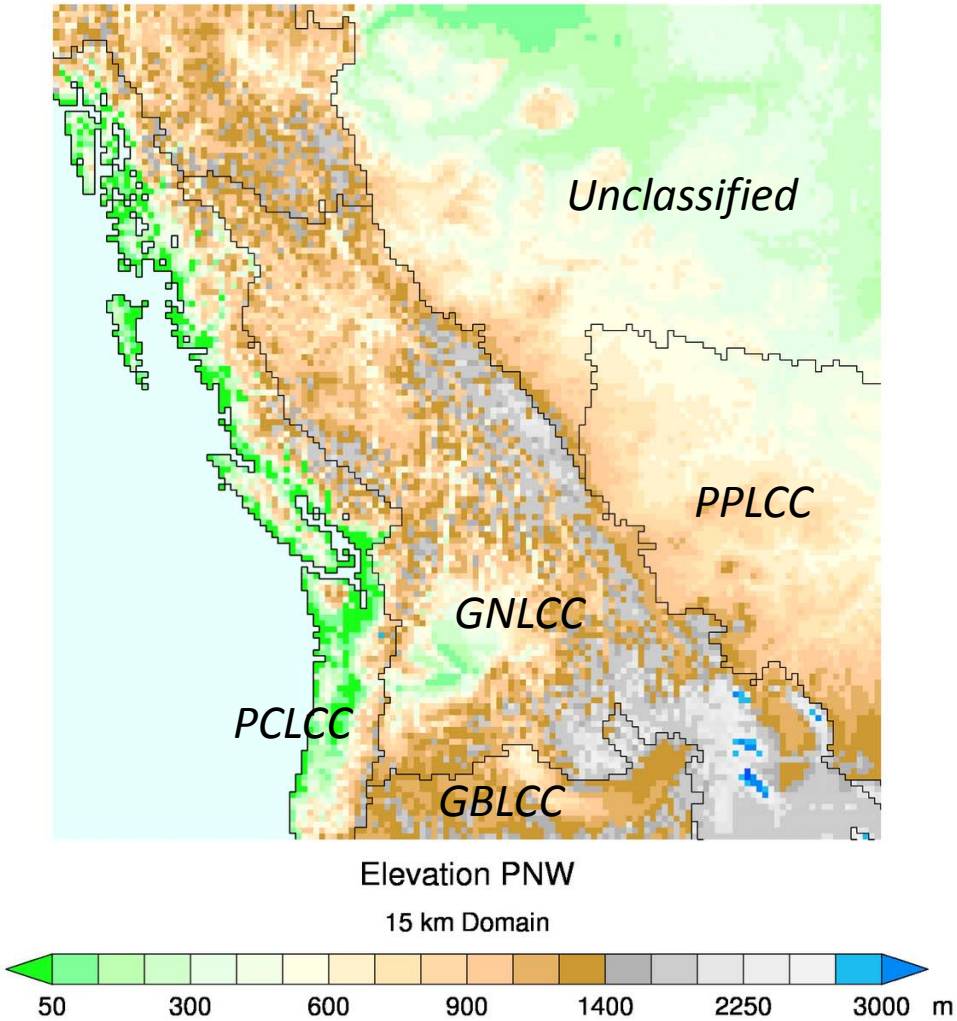
Simulated Interannual



Present versus future PNA

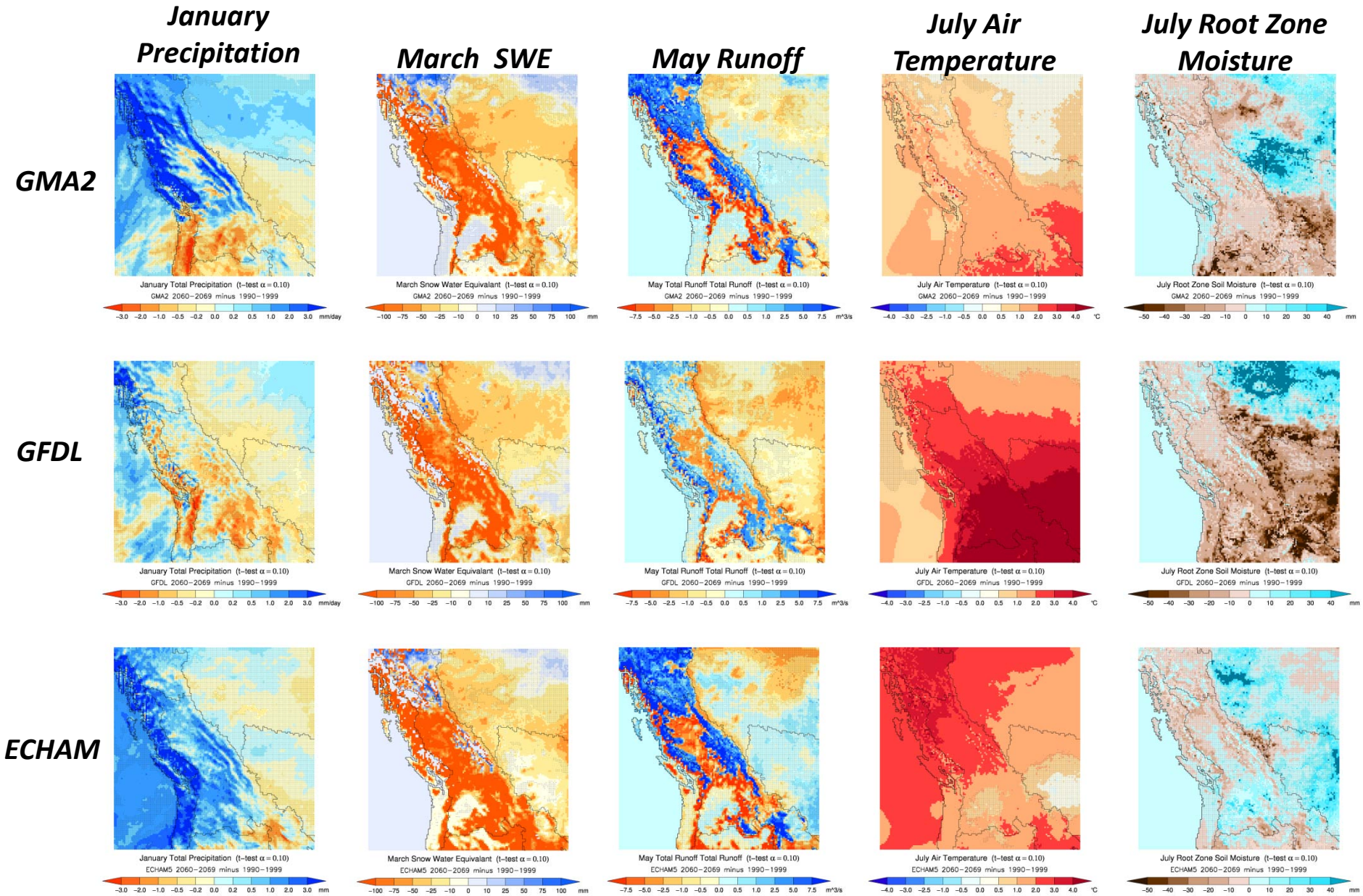


Pacific Northwest Quadrant



Climate variables relevant to aquatic systems

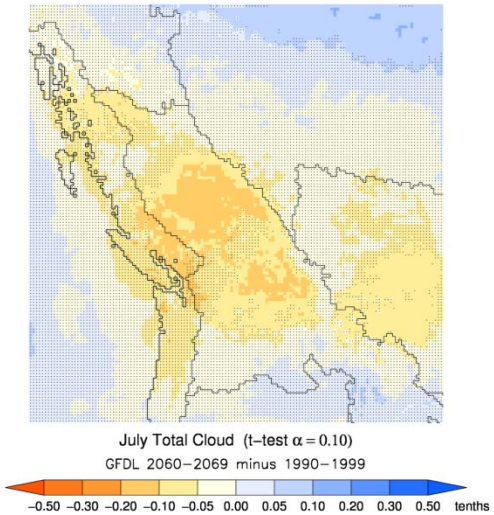
2060-2069 minus 1990-1999



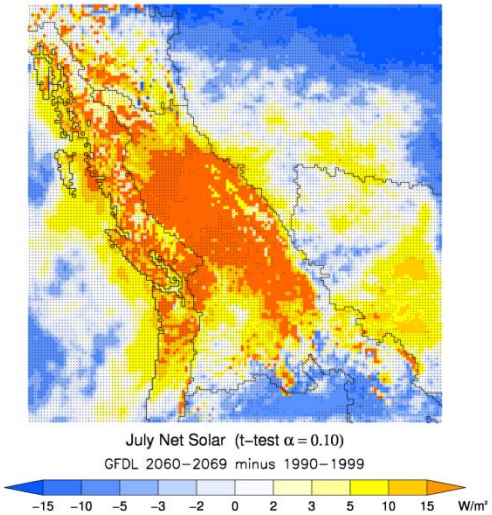
Changes in energy and water inputs

2060-2069 minus 1990-1999

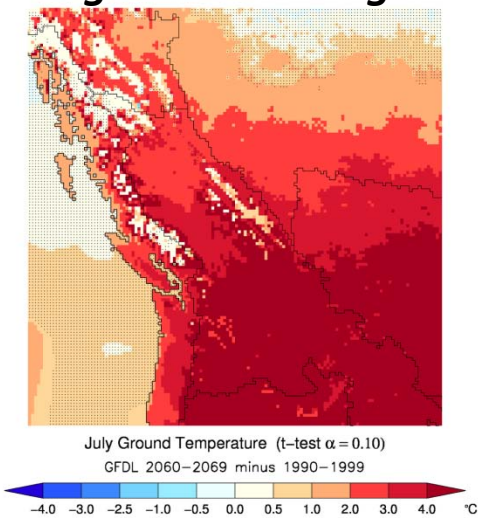
cloud cover



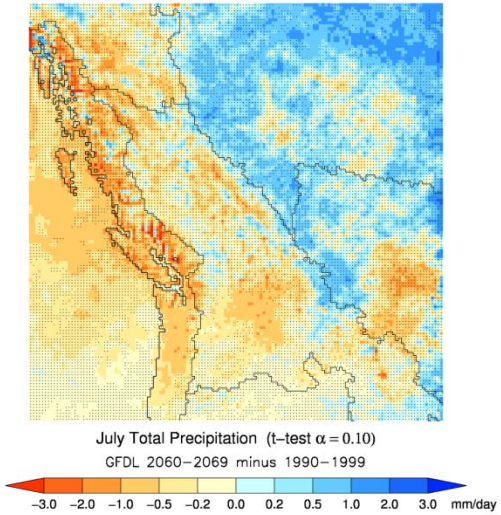
solar radiation



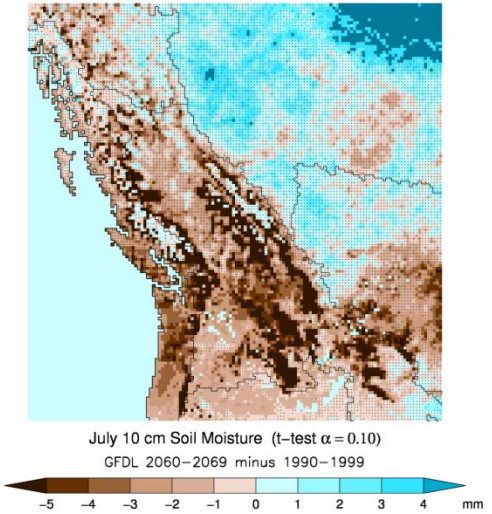
ground heating



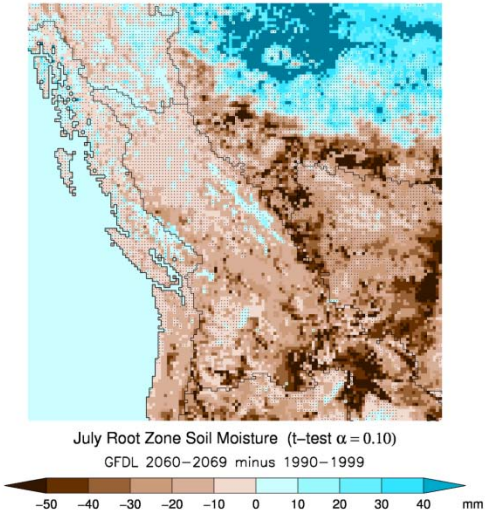
precipitation



10 cm soil moisture (~small fuel)

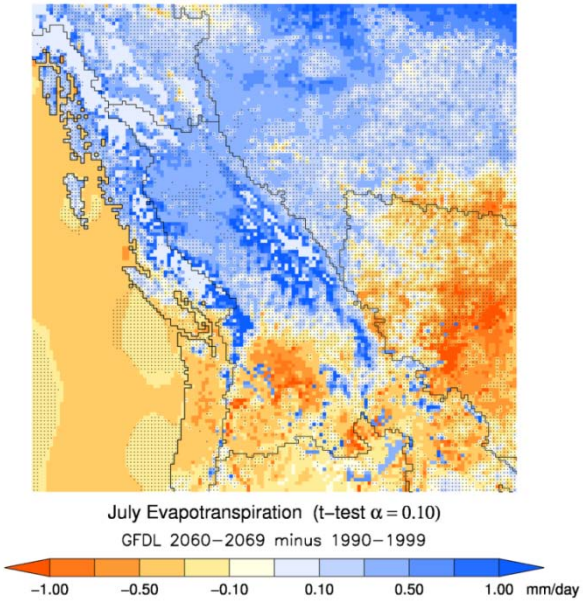


Root zone soil moisture (~large fuel)

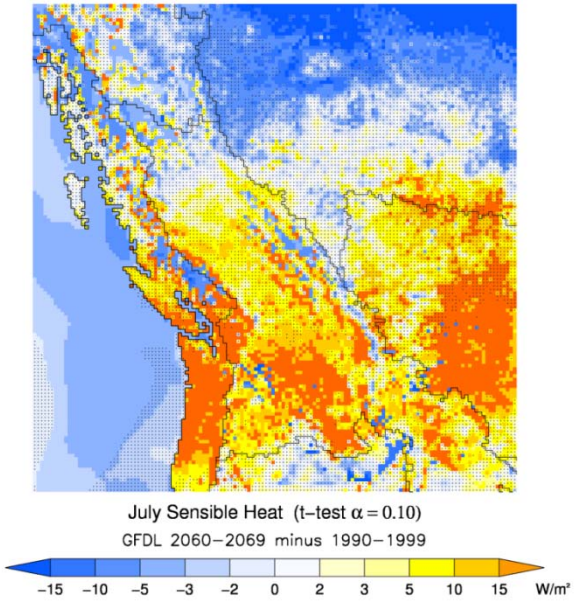


More energy combined with less water leads to reapportioning of energy from latent heat into sensible heat (Bowen ratio $\beta = \frac{SH}{LE}$)

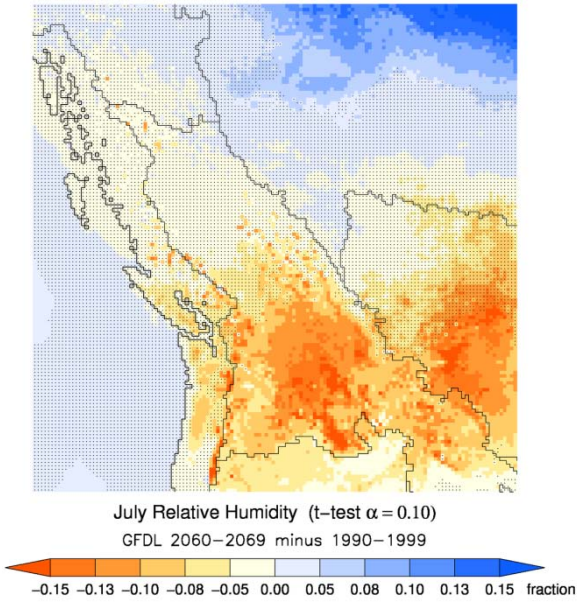
ET (latent heat flux)



Sensible heat flux



Relative Humidity



… combined with lower RH ⇨ ***more favorable wildfire conditions***

Dynamically downscaled climate simulations over North America: Climate analysis and guidance for management decisions

Preliminary data not for release before approval by the US Geological Survey

This beta-version is being continuously revised and is not ready for general access. You are part of a limited group with access to this site for the purpose of providing comments, criticisms and suggestions that will improve our ability to provide useful access to climate data. Please do not distribute the link to this site.

Background

Regional Model Description and Implementation

Driving Global Models

Description of Available Data

Evaluation of Data and Guidance for Users

North America (50km)

Eastern North America (15km)

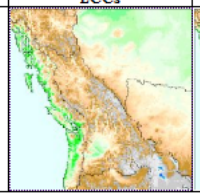
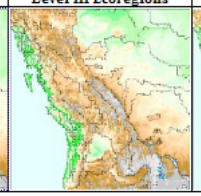
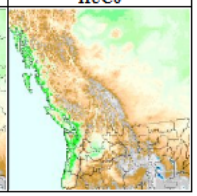
Pacific Northwest (15km)

Pacific Southwest (15km)

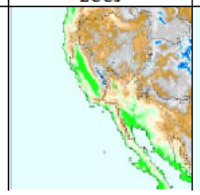
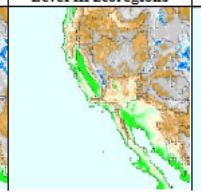
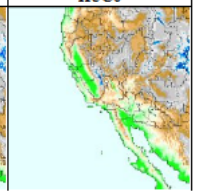
Northern Rocky Mountains (15km)

Southern Rocky Mountains (15km)

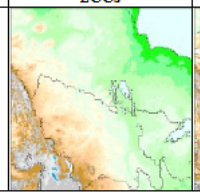
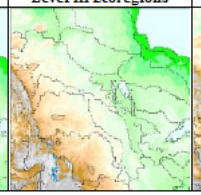
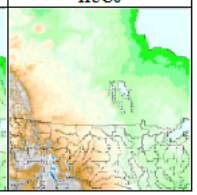
Pacific Northwest (15km)

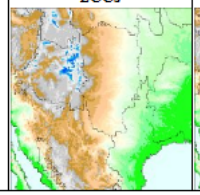
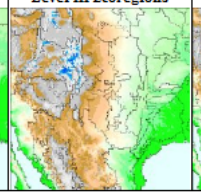
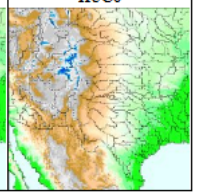
Description	State Boundaries	LCCs	Level III Ecoregions	HUC6
Pacific Northwest Simulations at 15 km Analyzed within State Boundaries, Landscape Conservation Cooperative Boundaries, EPA Level III Ecoregions and Hydrologic Unit Codes 6. (Select Analysis by Clicking on Map)				

Pacific Southwest (15km)

Description	State Boundaries	LCCs	Level III Ecoregions	HUC6
Pacific Southwest Simulations at 15 km Analyzed within State Boundaries, Landscape Conservation Cooperative Boundaries, EPA Level III Ecoregions and Hydrologic Unit Codes 6. (Select Analysis by Clicking on Map)				

Northern Rocky Mountains (15km)

Description	State Boundaries	LCCs	Level III Ecoregions	HUC6
Northern Rocky Mountains Simulations at 15 km Analyzed within State Boundaries, Landscape Conservation Cooperative Boundaries, EPA Level III Ecoregions and Hydrologic Unit Codes 6. (Select Analysis by Clicking on Map)				

Southern Rocky Mountains (15km)

Description	State Boundaries	LCCs	Level III Ecoregions	HUC6
Southern Rocky Mountains Simulations at 15 km Analyzed within State Boundaries, Landscape Conservation Cooperative Boundaries, EPA Level III Ecoregions and Hydrologic Unit Codes 6. (Select Analysis by Clicking on Map)